NASA Innovative Advanced Concepts

MAGNETOUR: Surfing Planetary Systems on Electromagnetic and Multi-Body Gravity Fields

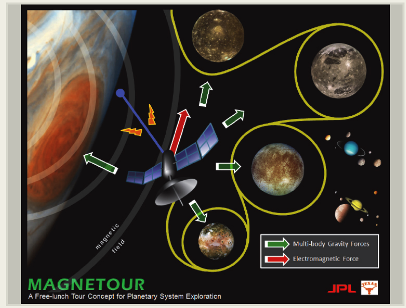
Completed Technology Project (2012 - 2013)

Project Introduction

MAGNETOUR enables a spacecraft to orbit and travel between multiple moons of an outer planet, using very little or even no propellant. To achieve this free-lunch 'Grand Tour', we exploit the unexplored combination of magnetic and multi-body gravitational fields of planetary systems. We propose a new mission concept, called MAGNETOUR, that enables a spacecraft to orbit and travel between multiple moons of an outer planet, using very little or even no propellant. To achieve this free-lunch 'Grand Tour', we exploit the unexplored combination of magnetic and multi-body gravitational fields of planetary systems. This concept involves combining two main innovations: Design of a very low delta-v tour of planetary moons by considering the intrinsic multi-body gravitational dynamics of planetary systems, and Use of the electromagnetic Lorentz force as a revolutionary means for performing the required low delta-v maneuvers of our low-energy tour.

Anticipated Benefits

A full study of the giant, complex outer planet systems is a central goal in space science. Exploring these systems can help us understand better our solar system as a whole. According to the Decadal Survey [1], a full exploration of planetary moon systems of Jupiter, Saturn and Uranus are top priorities for the next flagship class tour and orbiting mission. In particular, a comprehensive visit of the four large moons of Jupiter, known as the "Galilean moons", is important to search for liquid water and extraterrestrial life. In this NIAC Phase One study, we propose a new mission concept, named Magnetour, to facilitate the exploration of outer planet systems and address both power and propulsion challenges. Our approach would enable a single spacecraft to orbit and travel between multiple moons of an outer planet, with no propellant required. Our approach would enable a single spacecraft to orbit and travel between multiple moons of an outer planet, with no propellant nor onboard power source required. To achieve this free-lunch 'Grand Tour', we exploit the unexplored combination of magnetic and multi-body gravitational fields of planetary systems, with a unique focus on using a bare tether for power and propulsion.



Project Image MAGNETOUR: Surfing Planetary Systems on Electromagnetic and Multi-Body Gravity Fields

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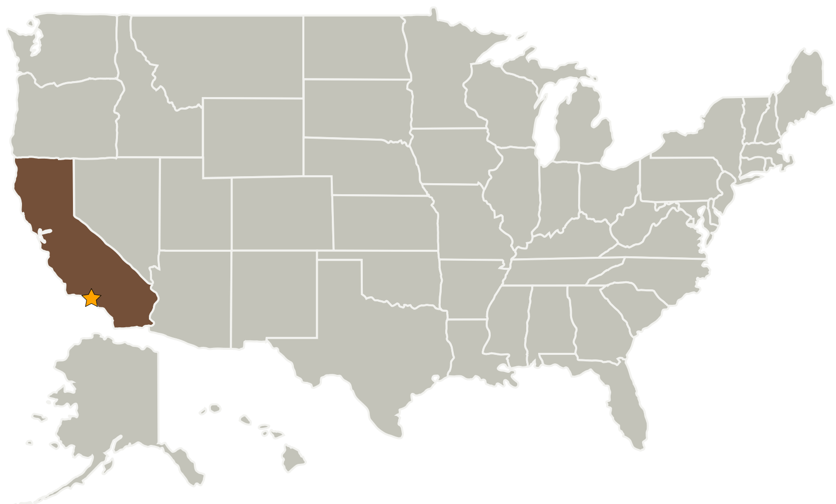
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Jet Propulsion Laboratory(JPL)	Lead Organization	NASA Center	Pasadena, California
The University of Texas at Austin	Supporting Organization	Academia	Austin, Texas

Primary U.S. Work Locations
California

Project Transitions

September 2012: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Jet Propulsion Laboratory (JPL)

Responsible Program:

NASA Innovative Advanced Concepts

Project Management

Program Director:

Jason E Derleth

Program Manager:

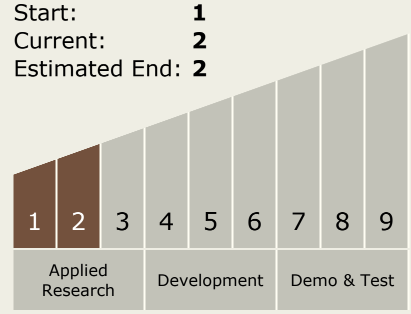
Eric A Eberly

Principal Investigator:

Gregory Lantoine

Technology Maturity (TRL)

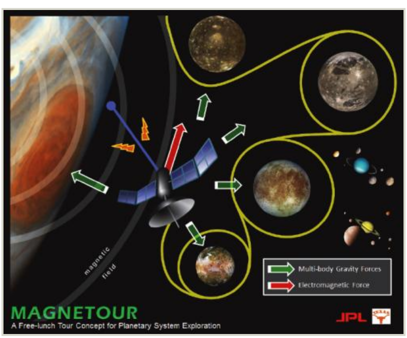
Start: **1**
Current: **2**
Estimated End: **2**



June 2013: Closed out

Closeout Summary: Using numerical simulations that incorporate simplified orbital mechanics and tether dynamics, our preliminary results suggest that a full propellantless concept relying on electrodynamic tethers only is indeed feasible at Jupiter. The concept requires a tether length of at least 20 km at Jupiter. Mass savings can be in the order of 800 kg compared to classical mission concepts and using currently available tether materials. We have developed a preliminary design for a 25-km long tether at Jupiter. The tether is used for capture and lowering the apojove by repeatedly turning on the tether at perijove. Moon flybys are then the most efficient method to raise perijove. A low-energy tour surfing the InterMoon Superhighway and orbiting successively Callisto, Ganymede and Europa requires 5 m/s only, a dramatic improvement over classical patched-conics tour designs. Additional interesting dynamical features can be also found by fully coupling the electromagnetic and gravitational dynamics. There are many extensions possible of the Magnetour concept that use part or all of the techniques considered in this study: 1. Outer planet cubesats: a tether could be attached to the cubesats to provide propulsion and power without significant mass penalty.
2. Outer planet sample return mission: the Magnetour concept could be augmented by adding a return trajectory leg to the Earth. The sampling of one or several of the moons could be performed by the tether itself during close flybys. 3. Jupiter observer at low circular orbit: a 'descope' Magnetour could simply involve a low circular orbit at Jupiter.

Images



11557-1366053384150.jpg
Project Image MAGNETOUR: Surfing Planetary Systems on Electromagnetic and Multi-Body Gravity Fields
(https://techport.nasa.gov/image/102082)

Technology Areas

Primary:

- TX01 Propulsion Systems
  └ TX01.2 Electric Space Propulsion
    └ TX01.2.3 Electromagnetic

Target Destination

Others Inside the Solar System